FINAL REPORT

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October 1, 1985—September 30, 1990

A. WORK DONE.

The study of robust procedures with special emphasis on rank based methods for a variety of problems connected with time series analysis was initiated. In this connection, a number of problems were satisfactorily solved, and a number of them remain to be solved; the goal has been to provide a unified optimal and robust rank based theory (of time series analysis) in a systematic and logically integrated form.

A first step towards a systematic development of this subject was taken in two papers by the principal investigator along with Hallin and Ingenbleek (see [1] and [2] under Publications, page 4) where asymptotically locally optimal and maximin–optimal rank tests were derived for the problem of testing randomness against alternatives of ARMA dependence (see also [3] and [4] under Publications, page 4). Two classes of serial rank statistics were introduced for that purpose. The first one was the class of linear serial rank statistics, of order p , of the form

$$S^{(n)} = (n-p)^{-1} \sum_{t=p+1}^{n} a^{(n)}(R_t^{(n)}, R_{t-1}^{(n)}, ..., R_{t-p}^{(n)}) \, ,$$

where $R_t^{(n)}$ denotes the rank of the observation $X_t^{(n)}$ in an observed series $\underline{X}^{(n)} = (X_1^{(n)}, ..., X_n^{(n)})$ of length n , and $a^{(n)}(...)$ is some score function. Of special interest is the particular linear serial rank statistic, namely, the rank autocorrelation $r_{i\,;\,f}^{(n)}$ of order i associated with density $f(\cdot)$ which enjoys most of the asymptotic properties of the usual sample autocorrelations $r_i^{(n)}$ for Gaussian series.

The second class of rank statistics considered was that of quadratic serial rank statistics, which were quadratic forms of linear serial rank statistics considered in [1]. Of particular interest were the rank portmanteau statistics $n\sum_{i=1}^{K}(r_{i\,;\,f}^{(n)})^2$ which provided a

rank—based version of Box and Pierce's classical <u>portmanteau</u> <u>statistics</u> $n\Sigma_{i=1}^{K}(r_i^{(n)})^2$.

In the third paper (see [5] under Publications, page 4), the problem of testing a given ARMA model (in which the density of generating white noise is unspecified) against other ARMA models was considered. A distribution—free asymptotically most powerful test, based on a <u>generalized</u> <u>linear</u> <u>serial</u> <u>rank</u> <u>statistic</u> was provided against contiguous alternatives with specified coefficients. In the case when the ARMA model in the alternative has unspecified coefficients, an asymptotically maximin most powerful test based on a <u>generalized</u> <u>quadratic</u> <u>serial</u> <u>rank</u> <u>statistic</u> was derived. The asymptotically maximin optimal test statistic turned out to be a rank—based, weighted version of the classical Box-Pierce portmanteau statistic, to which it reduces, in some particular problems, under Gaussian assumptions. Some of these results appeared in the <u>Proceedings</u> <u>of</u> <u>the</u> <u>National</u> <u>Academy</u> <u>of</u> <u>Sciences,</u> <u>U.S.A.</u> (see [6] under Publications, page 4).

Another major problem investigated was that of testing <u>multivariate</u> randomness against serial dependence (see [7] and [8] under Publications, page 4). Here a class of serial <u>multirank</u> statistics was introduced for the problem of testing the null hypothesis that a multivariate series of observations is white noise against alternatives of ARMA dependence. The statistics developed were shown to provide permutationally distribution—free tests that are asymptotically most powerful against specified local alternatives. In particular, a test of the van der Waerden type was shown to be asymptotically as powerful as the corresponding normal theory parametric test based on classical sample cross-covariance matrices.

Another problem dealing with the statistical analysis of ARMA models via signed-rank tests was studied (see [9] under Publications, page 4). It is well known that, in the case of an exchangeable series of observations with unspecified but symmetric (w.r.t. zero) density, the maximal invariant is the vector of <u>signed</u> <u>ranks</u> (i.e. the ranks of absolute

values, together with the signs of the observations). The choice between ranks and signed ranks in classical linear models is fixed by the (testing or estimation) problem to be considered. This is not the case, apparently, in problems dealing with serial dependencies (i.e. testing an ARMA model or estimating its parameters), where both the ranks and the signed ranks can be used with the same purpose, and presumably yield asymptotically equivalent performances. Since no theory dealing with signed–rank serial statistics was ever developed, we studied in publication [9] the asymptotic distribution theory of linear serial signed rank statistics; we introduced the concept of signed–rank autocorrelation coefficient, and used it in deriving asymptotically optimal signed–rank tests for a variety of problems dealing with the serial dependence structure of an observed series. Finally, we compared the powers of the proposed tests with those of their parametric competitors, and established the superiority of our procedures.

Other time series problems or problems with applications in time series considered were "Weak convergence of serial rank statistics under dependencies with applications in time series and Markov processes", Annals of Probability (see [10] and [11], under Publications, page 5); "Limiting behavior of U–statistics, V–statistics and one sample rank order statistics for nonstationary absolutely regular processes", Journal of Multivariate Analysis (see [12] under Publications, page 5); "Weak convergence of the U–statistic and weak invariance of the one sample rank order statistic for Markov processes and ARMA models", Journal of Multivariate Analysis (see [13] under Publications, page 5), "Weak invariance of generalized U–statistics for nonstationary absolutely regular processes", Stochastic Processes and Their Applications (see [14] under Publications, page 5), "Locally asymptotically optimal tests for randomness", (see [15] under Publications, page 5); "On time–reversibility and the uniqueness of moving average representations for non–Gaussian stationary time series", Biometrika (see [16] under Publications, page 5); "Maximum likelihood estimation for stationary point processes", Proceedings of the National Academy of Sciences (see [17] under Publications, page 5). See also [18] and the related papers [19],

[20], [21], [22], [23], [24], [25] and [26] under Publications, pages 5 and 6. In addition, some problems connected with the theory of fuzzy random variables, estimation theory, order statistics, permutation procedures, adaptive procedures, stochastic processes, limit theorems and rates of convergence for rank order statistics were studied. These are also listed under Publications (see pages 6 to 8).

B.   PUBLICATIONS UNDER THE OFFICE OF NAVAL RESEARCH GRANT
N00014–85–K–0648   from October 1, 1985 to September 30, 1990.

[1]   M.L. Puri, "Linear serial rank tests for randomness against ARMA alternatives", Annals of Statistics (1985) 13, 1156–1181 (joint with Marc Hallin and Jean–Francois Ingenbleek).

[2]   M.L. Puri, "Linear and quadratic serial rank tests for randomness against serial dependence", Journal of Time Series Analysis (1987) 8, 409–424 (joint with Marc Hallin and Jean–François Ingenbleek).

[3]   M.L. Puri, "Tests de rangs linéaires pour une hypothèse de bruit blanc", C.R. Acad. Sc. Paris (1985) 301, Série I, 49–52 (joint with Marc Hallin and Jean-Francois Ingenbleek).

[4]   M.L. Puri, "Tests de rangs quadratiques pour une hypothèse de bruit blanc", C.R. Acad. Sc. Paris (1985) 301, Série I, 935–938 (joint with Marc Hallin and Jean–Francois Ingenbleek).

[5]   M.L. Puri, "Optimal rank–based procedures for time series analysis: testing an ARMA model against other ARMA models", Annals of Statistics (1988) 16, 402–432 (joint with Marc Hallin).

[6]   M.L. Puri, "Locally asymptotically optimal rank–based procedures for testing ARMA dependence", Proceedings of the National Academy of Sciences, U.S.A. (1988) 85, 2031–2035 (joint with Marc Hallin).

[7]   M.L. Puri, "Asymptotically most powerful rank tests for multivariate randomness against serial dependence", Journal of Multivariate Analysis (1989) 30, 34–71 (joint with Marc Hallin and Jean–François Ingenbleek).

[8]   M.L. Puri, "Tests de rangs localement optimaux pour une hypothèse de bruit blanc multivarié", C.R. Academy of Sciences, Paris (1986) 303, Série I, 901–904 (joint with Marc Hallin and Jean–François Ingenbleek).

[9]   M.L. Puri, "Time series analysis via rank–order theory: signed–rank tests for ARMA models", Journal of Multivariate Analysis (1991) 39, 1–29 (joint with Marc Hallin).

[10]   M.L. Puri, "Weak convergence of serial rank statistics under dependence with applications in time series and Markov processes", Annals of Probability (1990) 18, 1361–1387 (joint with Michel Harel).

[11]   M.L. Puri, "Convergence faible de la statistique serielle linéaire de rang en condition de dépendance avec applications aux séries chronologiques et processus de Markov", C.R. Academy of Sciences, Paris (1987) 304, Série I, 583–586 (joint with Michel Harel).

[12]   M.L. Puri, "Limiting behavior of U–statistics, V–statistics and one–sample rank order statistics for nonstationary absolutely regular processes", Journal of Multivariate Analysis (1988), 30, 181–204 (joint with Michel Harel).

[13]   M.L. Puri, "Weak convergence of the U–statistic and weak invariance of the one–sample rank order statistic for Markov processes and ARMA models", Journal of Multivariate Analysis (1988), 31, 258–265 (joint with Michel Harel).

[14]   M.L. Puri, "Weak invariance of generalized U–statistics for nonstationary absolutely regular processes", Stochastic Processes and Their Applications (1990), 34, 341–360 (joint with Michel Harel).

[15]   M.L. Puri, Locally asymptotically optimal tests for randomness, New Perspectives in Theoretical and Applied Statistics, John Wiley and Sons, New York (1987) 87–99 (joint with Marc Hallin).

[16]   M.L. Puri, "On time–reversibility and the uniqueness of moving average representations for non–Gaussian stationary time series", Biometrika (1988) 75, 170–171 (joint with Marc Hallin and Claude Lefevre).

[17]   M.L. Puri, "Maximum likelihood estimation for stationary point processes", Proceedings of the National Academy of Sciences, U.S.A. (1986) 83, 541–545 (joint with Pham D. Tuan).

[18]   M.L. Puri, "Les tests de rangs dans l'analyse des series chronologiques", Cahiers du C.E.R.O. (1986) 28, 41–55 (joint with Marc Hallin and Jean–François Ingenbleek).

[19]   M.L. Puri, "Convergence faible du processus empirique multidimensionnel corrigé en condition de mélange", C.R. Academy of Sciences, Paris (1987) 305, Série I, 93–95 (joint with Michel Harel).

[20]   M.L. Puri, "Weak convergence of weighted multivariate empirical processes under mixing conditions", Proceedings of the Sixth Pannonian Symposium on Mathematical Statistics, Volume A: Mathematical Statistics and Probability, Reidel Publication Company, Holland (1987) 121–141 (joint with Michel Harel).

[21]   M.L. Puri, "Solutions fortes des équations différentielles stochastiques pour des processus à indice multidimensionnel", C.R. Acad. Sc. Paris (1985) 301, Série I, 845–848 (joint with Markus Dozzi).

[22]   M.L. Puri, "Strong solutions of stochastic differential equations for multiparameter processes", Stochastics (1986) 17, 19–41 (joint with Markus Dozzi).

[23] M.L. Puri, "Asymptotic normality of a class of nonparametric statistics", Econometric Theory (1987) 3, 313–347 (joint with Munsup Seoh).

[24] M.L. Puri, "Central limit theorems under alternatives for a broad class of nonparametric statistics", Journal of Statistical Planning and Inference (1989) 22, 271–294 (joint with Munsup Seoh).

[25] M.L. Puri, "On locally asymptotically maximin tests for ARMA processes", In Statistical Theory and Data Analysis II (Editor: K. Matusita) (1988) 495–499. North Holland Publishing Company (joint with Marc Hallin).

[26] M.L. Puri, "Asymptotic normality of L–statistics based on decomposible time series", Journal of Multivariate Analysis (1990) 35, 260–275 (joint with K.C. Chanda and F.H. Ruymgaart).

[27] M.L. Puri, "An invariance principle for processes indexed by two parameters and some statistical applications", Probability and Mathematical Statistics (1988) 9, 25–76 (joint with Manfred Denker).

[28] M.L. Puri, "The concept of normality for fuzzy random variables", Annals of Probability (1985) 31, 1373–1379 (joint with Dan A. Ralescu).

[29] M.L. Puri, "Limit theorems for fuzzy random variables", Proceedings of the Royal Society of London (1986) 407, 171–182 (joint with E.P. Klement and D.A. Ralescu).

[30] M.L. Puri, "The order of normal approximation for signed linear rank statistics", Teoria Veroyatnostei i ee Primeneniya (also in Theory of Probability and Its Applications, Translation by SIAM) (1986) 31, 156–163 (joint with Tiee–Jian Wu).

[31] M.L. Puri, "Linear rank statistics, bounded operators and weak convergence", New Perspectives in Theoretical and Applied Statistics, John Wiley and Sons, New York (1987) 171–206 (joint with Manfred Denker and Gerhard Keller).

[32] M.L. Puri, "Adaptive nonparametric procedures and applications", Journal of the Royal Statistical Society, Series C (Applied Statistics) (1988) 37205–218 (joint with N.J. Hill and A.R. Padmanabhan).

[33] M.L. Puri, "Asymptotic properties of linear functions of order statistics", Journal of Statistical Planning and Inference (1988) 8, 203–223 (joint with Cheun–Der Lea).

[34] M.L. Puri, "Asymptotic properties of perturbed empirical distribution functions evaluated at a random point", Journal of Statistical Planning and Inference (1988) 19, 201–215 (joint with Cheun–Der Lea).

[35] M.L. Puri, "Limit theorems for random central order statistics" In Adaptive Statistical Procedures and Related Topics, IMS Lecture Notes and Monograph Series (1987) 8, 447–475.

[36] M.L. Puri, "On admissible estimation in exponential families with imprecise information", In Statistical Decision Theory and Related Topics IV (1987), 403–408. Springer Verlag. (Edited by S.S. Gupta and James Berger).

[37] M.L. Puri, "Asymptotic behavior of multi–response permutation procedures", Advances in Applied Mathematics (1988) 9, 200–210 (joint with Manfred Denker).

[38] M.L. Puri, "Almost sure linearity for signed rank statistics in the non–i.i.d. case", Acta Mathematica Hungarica (1986) 48, 273–284 (joint with Stefan S. Ralescu).

[39] M.L. Puri, "L'espace $\tilde{D}_k$ et la convergence faible du processus empirique indexé par rectangles en condition de mélange", C.R. Academy of Sciences, Paris (1988) 306, Série I, 207–210 (joint with Michel Harel).

[40] M.L. Puri, "Comportement limite de la U–statistique, de la V–statistique et d'une statistique de rang à un échantillon pour des processus absolument réguliers non stationnaires", C.R. Academy of Sciences, Paris (1988) 306, Série I, 625–628 (joint with Michel Harel).

[41] M.L. Puri, "Tests de rangs signés localement optimaux pour une hypothèse de dépendance ARMA", C.R. Academy of Sciences, Paris (1988) 307, Série I, 355–358 (joint with Marc Hallin).

[42] M.L. Puri, "Convergence faible de la statistique sérielle linéaire de rang avec des fonctions de scores et des constantes de régression non bornées en condition de mélange", C.R. Academy of Sciences, Paris (1988) 307, Série I, 617–620 (joint with Michel Harel).

[43] M.L. Puri, "Asymptotic expansions for sums of nonidentically distributed Bernoulli random variables, Journal of Multivariate Analysis (1989) 28, 282–303 (joint with Paul Deheuvels and Stefan Ralescu).

[44] M.L. Puri, "On the rate of convergence in normal approximation and large deviation probabilities for a class of statistics", Teoria Veroyatnostei i ee Primeneniya (also in Theory of Probability and Its Applications, Translation by SIAM) (1989) 33, 735–750 (joint with Munsup Seoh).

[45] M.L. Puri, "A new semigroup technique in Poisson approximation", Semigroup Forum (1989) 38. 189–201 (joint with Paul Deheuvels and Dietmar Pfeifer).

[46] M.L. Puri, "Convergence faible de la U–statistique generalisée pour des processes nonstationnaires absolument réguliers, C.R. Academy of Sciences, Paris (1989) 309, Série I, 135–138 (joint with Michel Harel).

[47] M.L. Puri, "Weak convergence of the serial linear rank statistics with unbounded scores and regression constants under mixing conditions", Journal of Statistical Planning and Inference (1990) 25, 163–186 (joint with Michel Harel).

[48] M.L. Puri, "A local algorithm for constructing nonnegative cubic splines", Journal of Approximation Theory (1991) 36, 204–221 (joint with Bernd Fischer and Gerhard Opfer).

[49]   M.L. Puri, "Information", In <u>Acting</u> <u>Under</u> <u>Uncertainty</u>: <u>Multidisciplinary</u> <u>Conceptions</u> (Editor: George von Furstenberg). Kluwer Academic Publishers, Boston/Dordrecht/Lancaster (1990), 451–469 (joint with Howard L. Resnikoff).

[50]   M.L. Puri, "Measure of information and contiguity", <u>Statistics</u> <u>and</u> <u>Probability</u> <u>Letters</u> (1990) $\underline{9}$, 223–228 (joint with Istvan Vincze).

[51]   M.L. Puri, "The space $\hat{D}_k$ and weak convergence for the rectangle–indexed processes under mixing", <u>Advances</u> <u>in</u> <u>Applied</u> <u>Mathematics</u> (1990) $\underline{11}$, 443–474 (joint with Michel Harel).

[52]   M.L. Puri, "Limiting behavior of one sample rank–order statistics with unbounded scores for nonstationary absolutely regular processes", <u>Journal</u> <u>of</u> <u>Statistical</u> <u>Planning</u> <u>and</u> <u>Inference</u> (1991) $\underline{27}$, 1–23 (joint with Michel Harel).

C.   <u>DOCTORAL</u> <u>DISSERTATION</u>:

Michel Harel, "Convergence faible de la statistique linéaire de rang pour des variables aléatoires faiblement dépendantes et non stationnaires", 1989 (Docteur Es–Sciences). (Thesis was defended at the University of Paris Sud (Orsay)).

D.   <u>HONORS/AWARDS</u> (from 1985 onward)

(i)   Received Multidisciplinary Seminar Program Award on the project, "The Treatment of Uncertainty in the Sciences: Impulses and Perspectives from Various Disciplines", from the Dean of Faculties and Vice–Chancellor, Academic Affairs, Indiana University, Bloomington (1987).

(ii)   Invited as a "Distinguished Visitor" in the London School of Economics and Political Science for one month under the sponsorship of the Suntory–Toyota International Center for Economics and Related Disciplines (1990).

(iii)   Received the Rothrock Faculty Teaching Award in recognition of outstanding teaching in the Department of Mathematics of Indiana University (1990).

E.   <u>PROFESSIONAL</u> <u>SERVICE</u> at National and International level (from 1985 onward)

(1)   Editor–in–Chief, Journal of Statistical Planning and Inference, September 1984—December 1988.

(2)   Member, Governing Board, Journal of Statistical Planning and Inference, January 1989— continuing.

(3)   Organizer of a session on "Asymptotic Methods in Statistics", in the III International Meeting of Statistics in the Basque Country, Bilbao, Spain, August 7–9, 1985.

(4) Member, Organizi.. 3 Committee, Fourth Midwest Statistics Conference, held in East Lansing, Michigan, November 8–9, 1985.

(5) Member, American Statistical Association Committee on Scientific Freedom and Human Rights, 1985–1987.

(6) Institute of Mathematical Statistics Representative on the American Association for the Advancement of Science Section Committee on Mathematics (A), February 20, 1987–February 19, 1990.

(7) Member, Cooperative Committee, Pacific Area Statistical Conference, Tokyo, Japan, December 10–12, 1986.

(8) Member, Program Committee of the Annual Meeting of the Institute of Mathematical Statistics, San Francisco, California, August 17–20, 1987.

(9) Organizer of a session on "Time Series Analysis" in the Annual Meeting of the Institute of Mathematical Statistics, San Francisco, California, August 17–20, 1987.

(10) Member, Program Committee of the meeting of the Institute of Mathematical Statistics, Honolulu, Hawaii, June 19888

(11) Organizer of a Session on Topics in Asymptotic Theory in the meeting of the Institute of Mathematical Statistics, Honolulu, Hawaii, June 1988.

(12) Member, Program Committee, Seventh MidWest Statistics Conference, Columbia, Missouri, October 1988.

(13) Member, Advisory–cum–Organizing Committee, International Conference (dedicated to R.C. Bose), Fort Collins, Colorado, 1989.

(14) Member, Governing Board of the Journal of Statistical Planning and Inference, March 1989–

(15) Member, Nominating Committee of the Institute of Mathematical Statistics, 1991.

(16) Member, Organizing Committee, The 3rd Pacific Area Statistical Conference, Tokyo, Japan, December 10–13, 1991.

(17) Member, Scientific Committee, 4th International Meeting of Statistics in the Basque Country, San Sebastian, Spain, August 3–7, 1992.

F. INVITED ADDRESSES

I. International: 1985–1990 (outside U.S.A. and Canada).

(1) III International Meeting of Statistics in the Basque Country, Bilbao, Spain, August 7 – 9, 1985, organizer and speaker in a session on "Asymptotic Methods in Statistics".

(2) 1986 International Statistical Symposium, Taipei, Republic of China, August 3–6, 1986.

(3) Sixth Pannonian Symposium on Mathematical Statistics, Bad Tatzmannsdorf, Austria, "Nonparametric approach to time series problems". (Plenary Speaker).

(4) Pacific Area Statistical Conference, Tokyo, Japan, December 10–12, 1986, "Time series analysis via rank order theory".

(5) University of Hamburg, Hamburg, West Germany, May 16–June 6, 1987.

(6) Freie Universität Berlin, Berlin, West Germany, "Time series analysis based on rank order theory", May 22, 1987.

(7) Technische Universität, Vienna, Austria, "Time series analysis based on rank order theory", May 25, 1987.

(8) University of Paris VI, Paris, France, "Time series analysis based on rank order theory", May 27, 1987.

(9) Technische Hochschule Aachen, West Germany, "Asymptotic normality, rates of convergence and large deviation probabilities for a class of statistics", June 4, 1987.

(10) University of Dortmund, West Germany, "Time series analysis based on rank order theory", June 5, 1987.

(11) University of Paris VI, Paris, France, June 8–11, 1989.

(12) University of Limoges, Limoges, France, "Linear models with autocorrelated errors", June 13, 1989.

(13) Universität Oldenburg, Oldenburg, West Germany, "Asymptotic normality, rates of convergence and large deviation probabilities for a class of statistics", June 15, 1989.

(14) V International Conference on Probability Theory and Mathematical Statistics, Vilnius, U.S.S.R., June 26–29, 1989, "Time series analysis based on rank order theory".

(15) Steklov Mathematical Institute, Moscow, U.S.S.R., June 29 – July 4, 1989, "Some limit theorems for perturbed empirical distribution functions".

(16) Steklov Mathematical Institute, Leningrad, U.S.S.R., "Rates of convergence and large deviation probabilities for a broad class of statistics", July 5, 1989.

(17)   A: 1 Franco–Belgian Meeting of Statisticians, Brussels, Belgium, "Asymptotic normality, rates of convergence and large deviation probabilities for a broad class of statistics", November 24, 1989.

(18)   University of Lille, Lille, France, "Some limit theorems for perturbed empirical distribution functions", November 29, 1989.

(19)   University of Paris XI, Orsay, France, "Optimal rank based procedures for time series analysis", November 30, 1989.

II. Invited Addresses 1985–1990 (within the United States and Canada)

1984–85:

University of Houston, Houston, Texas; Symposium on "Adaptive Statistical Procedures and Related Topics" in Honor of Professor Herbert Robbins 70th Birthday. June 8 – 11, 1985, Brookhaven National Laboratory, Upton, New York (Plenary Lecture).

1985–86:

University of Maryland, College Park, Maryland (two lectures); The Catholic University of America; Fourth Purdue Symposium on Decision Theory and Related Topics, Purdue University, West Lafayette, Indiana.

1986–87:

Wright State University, Dayton. Ohio; McMaster University. Hamilton. Canada.

Invited by the National Education Committee of the People's Republic of China to give lectures in Tianjin. Beijing, Shanghai and Hangszhou.

1987–88:

MidWest Statistics Conference, University of Illinois, Champaign–Urbana. Illinois: Virginia Polytechnic Institute and State University, Blacksburg. Virginia (two lectures): Temple University, Philadelphia, Pennsylvania: Pennsylvania State University, University Park, Pennsylvania: Virginia Academy of Science, Chapter of American Statistical Association (guest lecture at the annual meeting), Charlottesville, Virginia: University of California, Davis, California: Institute of Mathematical Statistics Pacific Meeting, Honolulu, Hawaii.

1988–89:

Purdue University, West Lafayette, Indiana; Ohio State University, Columbus, Ohio; Nathan S. Kline Institute for Psychiatric Research, Orangeburg, New York; University of Waterloo, Ontario, Canada.

1989–90:

American Mathematical Society, Special Session on Statistics and
Probability, Muncie, Indiana (October 27–28); Southern Methodist
University, Dallas, Texas; Université Laval, Québec, Canada.

1990:

Institute for Mathematics and Its Applications (International
Interdisciplinary Workshop on Time Series Analysis, July 2–27, 1990),
Minneapolis, Minnesota; Office of Naval Research, Workshop on New
Directions in Statistics (November 19–20, 1990), Arlington, Virginia.

III.   OTHER INVITED ADDRESSES:

Invited Speaker at the Annual Meetings of the Institute of Mathematical
Statistics (1968 in Madison, Wisconsin; 1970 in Laramie, Wyoming; 1973 in
New York; 1977 in New Delhi, India; 1987 in San Francisco, California).

Gave two lectures to the American Statistical Association (under Survey of
Contemporary Statistics).

Respectfully submitted,

Madan Puri

Madan L. Puri
Professor